

Citation Index : An Indispensable Information Retrieval Tool For Research And Evaluation

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Abstract

This paper highlights the information explosion, the need for bibliographic control, the need for information retrieval tools. Explains the emergence of Citation Index, concept of citation indexing, reasons for citing, its structure (print and electronic versions of Science Citation Index and Social Science Citation Index), and application of citation index. It also discusses the search effectiveness, factors taken into consideration for coverage of journals in citation indexes, Journal Citation Reports, various latest citation products including the Web of Science and limitations of citation indexes.

Introduction

William Thomson one of the greatest scientists of the Nineteenth century said: “Scientific wealth tends to accumulate according to the law of compound interest.” Whether we consider that he was right or not depends on how we choose to define ‘scientific wealth’. In simple terms he was obviously right; if we measure the wealth of science by its size, then it has certainly grown at compound interest for most of the 20th century. The number of people who, according to the statisticians, are engaged in ‘scientific research and development’ in Western Europe and the USA increases by about 5 per cent per annum, which means that the total number doubles every 14 years. A simple calculation yields the astonishing result that about 90 per cent of all the scientists who have ever lived are alive today [1].

Every sphere of human knowledge has proliferated (Information Explosion) in the similar fashion. If you look at the 21st edition of Dewey Decimal Classification and compare with the older editions one can guess at what alarming speed the knowledge is growing. The growth of science is best illustrated by the number of scientific journals which are now being published; it has grown from two journals in the year 1665 the “*Journal des Scavans*” and “*Philosophical Transactions*” to well over 100,000 at the present. Derek J. Solla Price[2] in his book *Science Since Babylon* (1961) has postulated that an increase by a factor of ten every fifty years: 10 periodicals in 1750 ; 100 in 1800 ; 1000 in 1850 ; and 10,000 in 1900. Based on this pattern, Price predicted that we might well be “on the way to the next milestone of a hundred thousand such journals.

This proliferation of scientific journals may be attributed to various reasons : Increase in R&D activity as a basis for national defense, space exploration, and industrial and economic development. Increase in the number of scientists and technologists active in R&D and publishing. Importance attached to publications as a measure of scientist’s

stature by his peers and employers. Increasing specialization and compartmentalization of science and technology. Developments in high speed and high quality printing technology. One can easily make out the proliferation of journal literature from the splitting of journals into several sections. e.g. Physical Review (vol.1, 1969) has split into as many as five sections (A – E). And a number of full text electronic journals is also growing at an alarming rate and discovered a more complex picture than the traditional print journal.

Need for Bibliographic Control

Proliferation of scientific literature emanating from many countries in various languages, increase in the number of scientists producing and using literature, and the need for rapid access to most recent literature – all these factors have emphasized the need for a bibliographic control to facilitate the identification, selection and acquisition of scientific literature cutting across the diversities of format, language, and national origin.

Many bibliographies were compiled, many subject bibliographies were brought out by individuals, librarians, and publishers. Abstracting and indexing services came into being to provide quick retrieval of information current and retrospective and substitute for full text documents for scientists and engineers. A very interesting account of the emergence and development of abstracts journals during the period 1790 – 1920 has been provided by Bruce Manzer [3] .

The period around the time of the First World War formed an important transition in the development of social sciences. The research literature of the social sciences and the secondary tools for controlling it have grown in a pattern that , as might be expected , closely parallels the development of the disciplines themselves. The social scientists looked towards for their models and also borrowed new understanding of the research process from the sciences.

During nineteenth century, many specialized abstracting and indexing journals came into being. Notable among these are :

Abstracting Journals

1. Pharmaceutisches Central – Blatt (1830-)
2. Engineering Index (1884-)
3. Science Abstracts (1898-)
4. Chemical Abstracts (1907-)
2. Biological Abstracts (1926-)
5. Child and Development Abstracts (1927-)
6. Psychological Abstracts (1927 -)
7. Dissertation Abstracts International (1937 -)
8. Bulletin Signaletique (1940-)
9. Mathematical Reviews ((1940-)
10. Excerpta Medica (1947-)

11. Applied Mechanics Reviews (1948-
12. Sociological Abstracts (1952 -)
13. Analytical Abstracts (1954-)
14. Refrativnyi Zhurnal (1954-)
15. Astronomy and Astrophysics Abstracts (1969-)
16. INIS Atom Index (1970-)

Indexing Journals

- Zoological Record (1864-)
2. Index Medicus (1879-)
3. Science Citation Index (1961 -)
4. Social Science Citation Index (1973-)
5. Arts and Humanities Citation Index (1978-)

Now many of these abstracting and indexing journals are available online through many database vendors like Dialog, STN etc., and in CD – ROM form which has made the researchers' life simple.

The bibliographic control of information in the Internet era has made even more complicated as many new sites are created and old sites are moved to new sites and some sites cease to exist.

Need for Unified Index Free from Semantic Problems

The volume of scientific literature grew exponentially as a result of increased R& D activity after World War II. This posed different problems for indexers and users of information. The shortcomings of traditional subject indexes resulted in duplication of scientific activity. The terms used in subject index were ambiguous. For example in 1964 Index Medicus, 'Seasonal variations in birth' is indexed under 'periodicity'. It was very difficult to assign labels to new concepts. The consistency could not remain due to different intellectual abilities and technical skills of indexers. These problems necessitated a unified index to scientific literature that was current, free from semantic difficulties and not dependent on the knowledge of subject indexers. The oldest citation index in use since 1873 is Shepherd's citation index a legal tool, owes its existence to American law, which operates under the doctrine of 'Stare Decisis' which means that all the courts must follow their precedents as well as those established by higher courts [4]. A former vice-president of the firm that produced Shepard's Citations, William C. Adair, wrote to Garfield in 1953, having read an article about the Welch Project in which Garfield had been involved to suggest the use of citation indexes for scientific literature. Thus inspired by Shepard's Citation Index and other later developments, Eugene Garfield brought out a multidisciplinary indexing tool in 1961 covering only 613 source journals known as 'Science Citation Index'. He also brought out companion additions, 'Social Science Citation Index' in 1973 and Arts and Humanities Citation Index in 1978.

Concept of Citation Indexing

Scientific journals publish papers, notes, reviews, corrections etc. Each of these items have title, authors' affiliation, text and lastly citations or foot notes or a bibliography. In authors' reference to previously recorded information identify much of the earlier work that is pertinent to the subject of his document. A citation is of course, a reference to some previously published work that is relevant to the argument the author wants to make. The author may be criticizing the earlier item, may be building on it, may be using it to enhance his or her argument, or may be acknowledging an early pioneer. May be an author makes a citation simply to imply that the author has read widely around his or her subject. Authors use citations to illustrate, to elaborate, to build on or to criticize. The author believes the earlier item is relevant and wishes to draw the reader's attention to it.

A citation, therefore, links the earlier cited paper to the later one that cites it. A citation index is built around these linkages, they are cited and citing papers [5].

Reasons for Citing

As explained above people cite ones paper in their paper for variety of reasons. Following are some of the important reasons for citing.

- Paying homage to pioneers
- Giving credit for related work
- Identifying methodology equipment etc.
- Providing background reading
- Correcting one's own work
- Correcting the work of others
- Criticizing the work of others
- Substantiating claims
- Alerting researchers to forthcoming work.
- Providing leads to poorly disseminated, poorly indexed or un-cited work
- Authenticating data and classes of fact—physical constants
- Identifying the original publications in which an idea or concept was discussed
- Identifying the original publication describing an eponymic concept or term as, e.g. Hodgkin's disease, Pareto' law, Friedel- Crafts reaction
- Disclaiming work or ideas of others
- Disputing priority claims of others

Structure of Citation Index

The printed version of Citation Index comes in four separate but interrelated parts. The exhibit –1 will show how one can make use of these indexes using different approaches to locate or retrieve a particular piece of information. E.g. When a researcher knows the name of the author who is active in his or her area of research, a topic of his or her interest, or the name of the institute where the work related to his or her interest is being carried out. Exhibit –2 will show the sample search and shows how these indexes are

used as supplement and complement to each other. In case of on-line and CD- ROM versions of Citation Indexes the search is made very simple and less time consuming. The typical full record from SCI on CD-ROM and SSCI on CD-ROM are given in Exhibits – 3 and 4 . Here also one needs to know the exact structure of the database and search strategies to exploit it to the maximum extent possible.

Application of Citation Indexing

Citation index is not only used for retrieval of information but also used as an evaluation tool for evaluating scientists for promotions, awards, awarding grants to research projects, prospective students seeking influential universities, evaluating institutions, predicting Nobel prize winners, understanding the growth of knowledge, it's branching and the direction over a period of time, evaluating periodicals and procurement of the most important journals in a library within limited budgets, connecting thread of invention by making use of patent citations, for making assessments to see how discoveries and advancements have developed over the years, making science policy decisions, etc. Following are the broad outlines of applications of citation index:

- As a search tool
 - Bibliographic – verification search
 - Eponymic search
 - Follow-up searches
 - Concept search
 - Specific question search
 - Multidisciplinary search
 - Quick state- of-the art search
 - Comprehensive bibliography search
- As a science management tool
 - Qualitative measure
 - Citation insights
 - Structural Relationships
- As a method of historical research into science
- Mapping the structure of science
 - Co-citation clustering
 - Mapping specialties
- Citation analysis of periodicals
- Citation analysis of scientists
- Patent literature

Questions that Citation Index Can Answer

- ☐ Has the paper been cited ?
- ☐ Has there been a review on this subject ?
- ☐ Has this theory been confirmed ?

- ❑ Has this work been extended ?
- ❑ Has the method been improved ?
- ❑ Has this suggestion been tried ?
- ❑ Has this patent been cited in the journal literature?
- ❑ Is there a new synthesis for this old compound ?
- ❑ Has this chemical been tested for biological activity ?
- ❑ Has this drug had a clinical evaluation ?
- ❑ Is this idea really original ?
- ❑ Was this “to-be-published” paper published and where ?
- ❑ Where is the full paper for this preliminary communication ?
- ❑ Has this technical report been published in a journal ?
- ❑ Have there been subsequent errata and correction notes published ?

Search Effectiveness of Citation Index

The important strength of citation index is its search effectiveness. This quality has two components. One is search productivity(Recall), which is concerned with finding the largest possible number of relevant papers. The other is search efficiency, which is concerned with minimizing the number of irrelevant papers the searcher must check out to identify the relevant ones.

Indexing depth is the primary quantitative measure of search effectiveness. The more indexing statements used, the more detailed the description of the document. As indexing depth increases, so does the probability that the searcher will satisfy his or her needs. Since the average article contains approximately 15 citations, a citation index has an average depth of 15 “terms.” Most traditional indexes can not afford to match this depth.

The precision of the description is a matter of semantics, which poses a series of problems in a subject index. The basic problem is that word usage varies from person to person. It is very difficult for the indexer to choose appropriate words as the nature of language is so dynamic that new words are introduced and old ones disappear, and new meanings attached to old words. Another problem is to standardization of terms to have consistency and quality of indexing reduces the richness and variety available to the indexers. Citations, used as indexing statements, provide search productivity, search effectiveness, efficiency by avoiding semantic problems, and made the search very simple and enhanced the speed of search.

Factors Considered to Cover Journals in Citation Index

It is not simply possible to cover all the journals that are being published mainly because the number is so big. Many so-called scientific journals that appear more frequently publish little, and many more journals do not last long enough to earn serious consideration and major reason is the economics. Therefore the ISI has devised the following main guidelines for coverage of journals in citation index.

Journal Selection

- Journals with English bibliographic data
- Peer – reviewed journal
- Publication standards
 - Timeliness of publication
 - Accuracy of content
 - Meaningful title of journal and papers
 - Global view of journal
 - Maintain these standards every year on a continuous basis
- Expert judgment
- Citation data
- Subscribers' recommendations
-

Journal Citation Reports (JCR)

Journal Citation Reports is an annual companion volume to Citation Index. It comes in two editions and is available in CD and microfiche forms. It is also available on the Web since 1999.

- Science Edition (Covers 4,500 leading international science journals)
- Social Sciences Edition (Covers 1400 leading international social sciences journals)

Journal Citation Reports is a comprehensive journal evaluation tool that provides :

Publisher Information	Publisher's name & address, etc.,
Citing Journal Listing	Information on journals which have been cited by the selected journal
Cited Journal Listing	Information on journals which have cited the selected journal
Source Data Listing	Information on no. of articles & references published in the selected journal
Impact Factor Calculation	Formula to calculate the average citation rate of a journal's articles in the preceding 2 years
	$\text{Impact Factor for 2001} = \frac{\text{Number of citations received in 2001 to 1999 and 2000 articles}}{\text{Number of articles published in 1999 and 2000}}$

Immediacy Index Calculation	Formula to calculate current year's citation rate of a journal	Number of citations received in 2001 to 2001 articles
	Immediacy Index for 2001 =	----- Number of articles published in 2001
Cited Half-Life Calculation	Formula to calculate the no. of years from the current year where 50% of the total citations received by the journal in the current year is cumulated	
Citing Half-Life Calculation	Formula to calculate the no. of years from the current year where 50% of the total citations given by the journal in the current year is cumulated	
Journal Title Changes	Title changes information	

Latest Citation Products

Institute for scientific Information, Philadelphia, brings out various Specialty Citation Indexes [6] in addition to Science Citation Index , Social Science Citation Index , Arts & Humanities Citation Indexes. These specialty indexes provide focused current and retrospective coverage of the journals, books, and proceedings in their specialties. They also include individually selected, relevant items from publications outside the core literature, important information that one might not ordinarily consult. Some of the specialty indexes are :

- Biochemistry & Biophysics Citation Index
- Biotechnology Citation Index
- Chemistry Citation Index
- Material Science Citation Index
- Neuroscience Citation Index
- CompuMath Citation Index

Web of Science

The release of the Web of Science in 1997 heralded a new era in information retrieval with its powerful, yet easy-to –use, web interface for cited reference searching. The web of Science [6] is an integrated web based database which provides seamless access to the

Science Citation Index Expanded , Social Science Citation Index, and Arts & Humanities Citation Index. It enables users to search current and retrospective multidisciplinary information from approximately 8,500 of the most prestigious, high impact research journals in the world. The Web of Science also provides a unique search method, cited reference searching. With it, users can navigate forward, backward, and through the literature, searching all disciplines and time span to uncover all the information relevant to their research. Users can also navigate to electronic full-text journal articles. Web of Science covers the back years of Science Citation Index (1945-), Social Science Citation Index (1956-), Arts & Humanities Citation Index (1975-) and updated weekly. It also provides abstracts since 1992.

Web of Science Corporate Editions

The Web of Science Corporate Editions [6] are tightly focused citation databases designed especially to meet the needs of biopharmaceutical and chemical researchers. Accessible exclusively through the Web of Science via standard web browser, these new database options provide the advantages of enhanced cited reference searching plus all the capabilities of Web of Science. Updated weekly on five- and ten- year rolling files, the Web of Science Corporate Editions may be searched independently or as a group. Following are the Web of Science Corporate Editions :

- Chemical Sciences Citation Index
- Clinical Medicine Citation Index
- Biosciences Citation Index

Limitations of Citation Index

In spite of its several merits and applications it has its own inherent deficiencies. One should be very careful while collecting data and carrying out citation analysis as it may contain some discrepancies [7]. Moed and Vrienes [8] presented a detailed analysis of discrepancies . Following are some of the limitations of citation index:

- First author gets weightage in citation index
- Homographs
 - More than one author listed under single name heading
- One author listed under multiple headings
 - Incorrect citation of name
 - Variant initials
 - Maiden and married name in case of female author
 - Authors with particle names (de, des, von, van, etc.)
 - Translated and transliterated names
- Variant reference to the same item
 - Year, volume, page,
 - Name of journal
- No provision to eliminate bias due to negative citations
- Lack of comprehensiveness
- Bias towards European countries

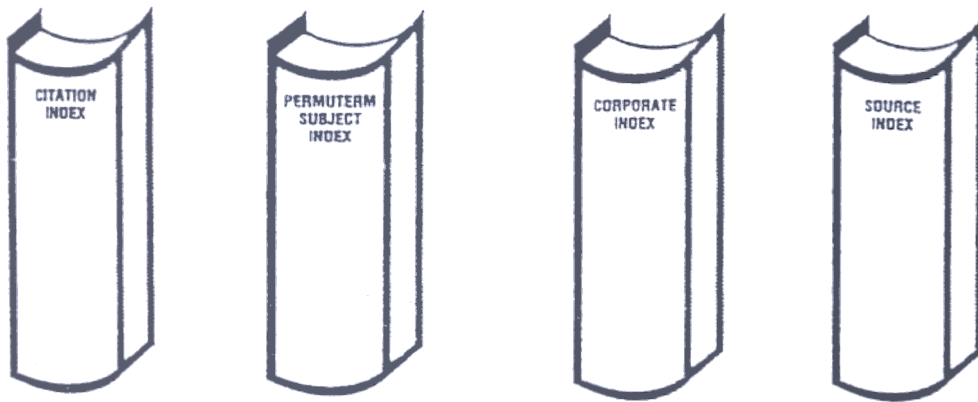
Conclusion

In the beginning citation indexes were considered as supplements to traditional indexes. Over a period of time citation indexes proved that they are fully integrated, comprehensive and independent information retrieval tools. Citation indexes are now used more for evaluation purpose such as evaluation of institutions, individuals, country, journals for subscription etc. than just using it as an information retrieval tool. Citation indexes are also used for predicting Nobel laureates, finding out citation classics, making assessments to see how discoveries and advancements have been made over the years, and making science policy decisions. If used properly taking the positive aspects, citation indexes may prove to be an indispensable tools for scientists, librarians, and science policy makers.

References

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2. Price, Derk J. de Solla, Science since Babylon, New Haven Conn : Yale University Press, 1963.
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8. Liu, M., The complexities of citation practice: A review of citation studies. *Journal of Documentation* .49(4), 1993, 370 –408.

Exhibit – 1 Structure of Citation Index (Print Version)



Searches usually begin in the *Citation Index*, the *Permuterm Subject Index* or the *Corporate Index*, and are completed in the *Source Index*.

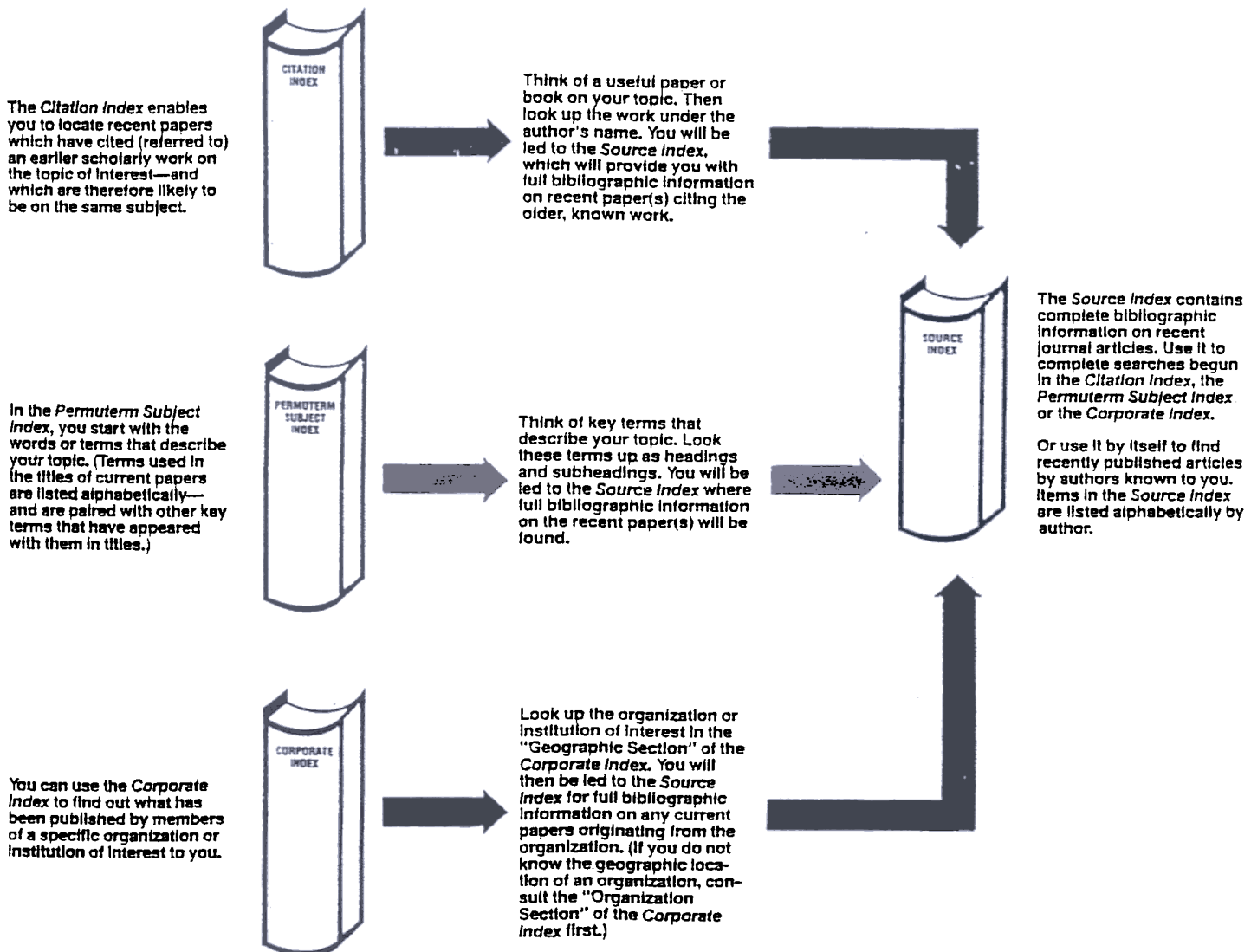


Exhibit - 2

SAMPLE SEARCH

(The index entries below are for illustration only.)

You are interested in locating recent papers on the subject of the *transmission of cytomegalo-virus in kidney transplants*.

Three starting points _____ leading to _____ same current article

1. The Citation Index

You know that in 1975, M. Ho wrote an article titled "The Transmission of Cytomegalo-virus in Kidney Transplants." This article was published in Vol. 293 of the *New England Journal of Medicine*, starting on page 1109.

CITATION					
cited author	HO M				
cited paper	75 NEW ENG J MED	293	1109		
	HAMILTON JD	TRANSPLANT	39	290	85
	KAGAN RJ	J TRAUMA	25	40	85
current authors who have cited this paper					

2. The Permuterm Subject Index

You think of words and phrases pertinent to your subject.

PSI		
primary term (heading)	CYTOMEGALO-VIRUS	
	KIDNEY	HAMILTON JD
	LABORATORY	SCHRIER RD
	LATENT	HAMILTON JD
	MURINE	HAMILTON JD
		SHANLEY JD
	SYNDROME	KRAMER A
		LEWIS JH
		MESSER G
		ZALOGA GP
	TISSUE-TRA.	HAMILTON JD
co-terms (subheadings)		authors of current papers

You complete your search by turning to the Source Index:

SOURCE		
author	HAMILTON JD	
co-author		
title	SEAWORTH BJ—TRANSMISSION OF LATENT CYTOMEGALO-VIRUS IN A MURINE KIDNEY TISSUE-TRANSPLANTATION MODEL	
journal in which article appeared	TRANSPLANT 39(3):290-296	85 57R
no. of references	VET ADM MED CTR, DEPT MED, DURHAM, NC 27705, USA	

3. The Corporate Index

You know that work on the subject you are researching is being done at the Veterans Administration Medical Center.

CORPORATE INDEX: ORGANIZATIONAL SECTION		
	VET ADM MED CTR, DEPT MED	
	NORTH CAROLINA	DURHAM
CORPORATE INDEX: GEOGRAPHIC SECTION		
	NORTH CAROLINA	
	DURHAM	
	•VET ADM MED CTR	
	•DEPT MED	
	HAMILTON JD	TRANSPLANT 39 290 85
	•EPILEPSY RES LAB	
	SAVAGE DO	J NEUROSC 5 408 85
	•SURG SERV	
	PARKER GA	J SURG ONC 28 36 85
authors from the organization who have recently published papers		

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 132 High Street, Uxbridge, Middlesex UB8 3DP, United Kingdom
 Telephone: 44-895-70016, Telex: 933693 UKISI

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Exhibit - 3

A typical full record from from SCI on CD -ROM

Authors: Saida-J Matsushita-M Zhang-T Inoue-A Chen-MW Sakurai-T
Title: Precipitation of Icosahedral Phase from a Supercooled Liquid Region in Zr₆₅Cu_{7.5}Al_{7.5}Ni₁₀Ag₁₀ Metallic-Glass
Full source: APPLIED PHYSICS LETTERS 1999, Vol 75, Iss 22, pp 3497-3499
Language: English
Document type: Article
IDS/Book No.: 258NT
No. Related Records: 20
No. cited references: 17
Author addresses: JAPAN-SCI-&-TECHNOL-CORP, ERATO, INOUE SUPERLIQUID GLASS PROJECT, SENDAI, MIYAGI 9820807, JAPAN
TOHOKU-UNIV, INST MAT RES, SENDAI, MIYAGI 9808577, JAPAN
KeyWords Plus: AL-CU-V; AMORPHOUS-ALLOYS; SI ALLOYS; CRYSTALLIZATION; TRANSITION; KINETICS
Abstract: The formation of an icosahedral phase from the rapidly quenched Zr₆₅Cu_{7.5}Al_{7.5}Ni₁₀Ag₁₀ metallic glass was confirmed and the kinetics of the precipitation upon isothermal annealing in the supercooled liquid region were examined by differential scanning calorimetry. Based on the kinetic analysis, it is clarified that the precipitation in the supercooled liquid region takes place by an interfacial controlled growth with a nearly steady-state nucleation rate. The Arrhenius plot between effective time lag, tau, of nucleation and isothermal annealing temperature yields a single linear relation, in which the activation energy for nucleation is evaluated to be 366 kJ/mol. It is concluded that the transformation of amorphous to quasicrystal proceeds by a homogeneous nucleation mode, which is different from those of Pd-U-Si and Al-Cu-V quasicrystals arising from an inhomogeneous distribution of quenched-in nuclei. (C) 1999 American Institute of Physics. [S0003-6951(99)04948-7].
Cited references: AVRAMI-M-1939-J-CHEM-PHYS-V7-P1103
BIZEN-Y-1988-TOYOTA-RES-REP-V41-P73
CHEN-LC-1988-NATURE-V336-P366
CHEN-MW-1999-APPL-PHYS-LETT-V75-P1697
ECKERT-J-1998-MATER-T-JIM-V39-P623
HOLZER-JC-1991-ACTA-METALL-MATER-V39-P1833
HOLZER-JC-1993-CRYSTAL-QUASICRYSTAL-P103
HORVATH-J-1990-LANDOLTBORNSTEIN-V26-P437
INOUE-A-1988-JPN-J-APPL-PHYS-PT-2-V27-P2248
INOUE-A-1990-MATER-T-JIM-V31-P104
INOUE-A-1990-MATER-T-JIM-V31-P177
JOHNSON-WA-1939-T-AM-I-MIN-MET-ENG-V135-P416
KAWASE-D-1993-APPL-PHYS-LETT-V62-P137
KOSTER-U-1996-APPL-PHYS-LETT-V69-P179
SHEN-Y-1986-PHYS-REV-B-V34-P3516
TSAI-AP-1989-ACTA-METALL-V37-P1443
XING-LQ-1999-APPL-PHYS-LETT-V74-P664

Exhibit - 4

A Typical Full record from SSCI on CD - ROM

Authors: Marlowe-MJ Smeeton-N Lipsedge-M
Title: Injection into Femoral and Jugular Veins by Opiate Misusers
Full source: ADDICTION RESEARCH 1997, Vol 5, Iss 1, pp 49-52
Language: English
Document type: Article
TGA/Book No.: XA939
No. Related Records: 8
No. cited references: 7
Author addresses: UNITED-MED-&-DENT-SCH, GUYS HOSP, SCH MED,
ACAD DEPT PSYCHIAT, 1ST FLOOR, LONDON SE1-9RT,
ENGLAND UNITED-MED-&-DENT-SCH, DEPT PUBL HLTH
MED, LONDON SE1-9RT, ENGLAND
GUYS-HOSP, LONDON SE1-9RT, ENGLAND
Author keywords: Opiate Misuse; Injection into Deep Veins; Early Antisocial
Behavior; **Child Abuse**
KeyWords Plus: DRUG; TRANSITIONS; ADDICTS; ROUTE

Abstract: The case notes of 69 consecutive intravenous opiate misusers attending an outpatient treatment unit were reviewed to explore possible factors associated with the use of femoral and jugular veins for injection. A longer history of treatment, a history of parental violence and/or abuse and evidence of early antisocial behaviour were associated with injection into deep veins. Replication of these results and further investigation of the hypothesis generated are recommended.

Cited references: BROONER-RK-1993-AM-J-PSYCHIAT-V150-P53
DESJARLAIS-DC-1992-BRIT-J-ADDICT-V87-P493
GHODSE-AH-1987-BRIT-J-PSYCHIAT-V151-P72
GRIFFITHS-P-1992-BRIT-J-ADDICT-V87-P485
MUGA-R-1990-BRIT-J-ADDICT-V85-P775
ROBINS-LN-1978-PSYCHOL-MED-V8-P611
STRANG-J-1992-BRIT-J-ADDICT-V87-P473